

Packaging and Reliability of Electronic Nose for Space Applications

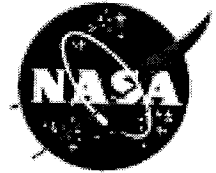
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ACKNOWLEDGEMENTS

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- * The assessment and package reliability of e-nose research work is supported by NASA Electronic Parts and Packaging Program (NEPP), Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA under a contract with the NASA - Code AE.**

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OUTLINE

- ★ Objectives
- ★ Introduction
- ★ Types of Sensors
- ★ JPL E-Nose test results
- ★ Reliability issues
- ★ COTS E-Nose program
- ★ Packaging and Qualification
- ★ Conclusion - Assess and Validate JPL E-Nose and COTS e-noses via collaboration within NASA and outside

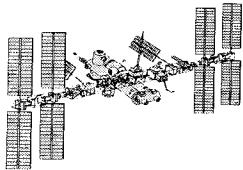
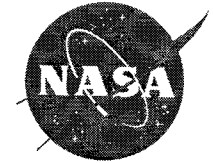
Packaging and Reliability Assessment of Electronic Noses

- An electronic nose is to identify an odorant sample and perhaps to estimate its concentration.
- COTS E-Noses and JPL E-Nose are being used for such applications.
- The e-nose could monitor indoor air quality as well as industrial and agricultural, and space shuttle cabins, and cabins of international space station such as hazardous alarms for toxic (ammonia, monomethylhydrazine, hydrazine, aromatic gas species, and inorganic gas species), biological agents etc.
- An electronic nose could be used to monitor electrical fires in control equipment and also high power electronics packaging systems for early detection of fire.
- We will address the assessment of reliability of e-nose sensor heads and related driver electronics packages of the respective e-nose to meet manufacturer's specifications and also assess beyond manufacturer's specifications that include to meet the requirements of NASA.



Electronic Nose

POSSIBLE APPLICATIONS



SPACE STATION ENVIRONMENTAL MONITORING

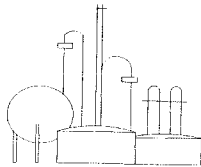
Event monitor for early warning of spills, leaks, fires; clean-up monitoring; automated environmental control.



MILITARY APPLICATIONS

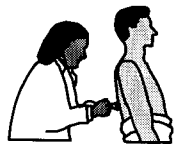
Air quality monitor for enclosed spaces.

Detection of explosives, chemical/biological warfare agents.



INDUSTRIAL MONITORING AND PROCESS CONTROL

Monitor food processing, identity and condition of raw materials, leaks and buildup of toxic compounds.



MEDICAL

Diagnosis of diseases with characteristic odors, monitor patients' rooms, monitor labs.



OTHER ENVIRONMENTAL MONITORING

Air quality in buildings, aircraft. Presence of toxic materials in designated spaces.



Rationale to NASA

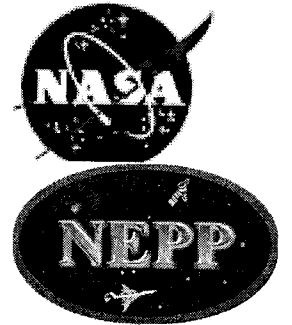


- ◆ No miniature gas sensors capable of detecting and identifying a broad suite of compounds
- ◆ GC-MS are capable of highly accurate analysis at very low levels require significant crew time to operate and maintain
- ◆ Lack of a monitor in crew quarters of space shuttle or space station
- ◆ Need of such capability is foreseen
- ◆ Air in the space station cannot be easily replaced
- ◆ Contaminants will build up over time
- ◆ Air quality should be monitored since crew health is important
- ◆ New technology infusion to create an integrated environmental monitoring and control system for the ISS and other missions.

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Definition



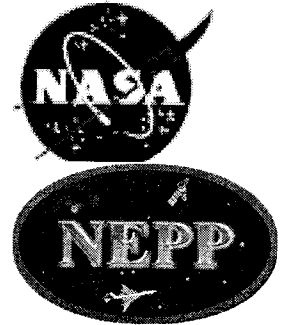
- ◆ Electronic noses are systems for the automated detection and classification of odors of simple and complex and it is generally composed of an array of chemical sensing systems and a pattern recognition system. Electronic noses are based on human olfactory system. (Gardner, 1988)
- ◆ Arrays of sensors, which respond to a wide range of compounds. (Chemical sensors, spectrometers)
- ◆ Advanced pattern recognition and artificial intelligence techniques, which enables to extract relevant and reliable information.(statistical methods such as principal component analysis, discriminant factorial analysis, cluster analysis or artificial neural networks)

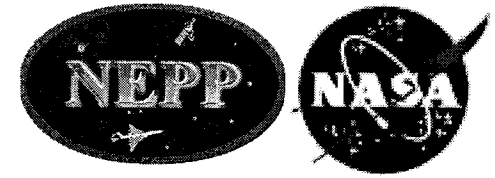
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SENSES

- ◆ Smell (Nose, Odor, good, bad, etc)
- ◆ Taste (Tongue, sweet, spice, sour, etc.)
- ◆ Feel (Touch, hard, soft, warm, cold)
- ◆ Listen (Ears, sound)
- ◆ See (Vision, Eyes, colors)



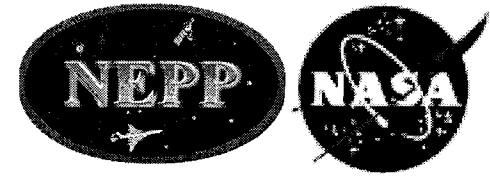


Objectives

- ◆ Develop, build, and demonstrate a miniature gas sensor, an E-Nose, for experiment on a shuttle flight (Accomplished by JPL)
- ◆ Assess the air quality monitor in crew habitat on a spacecraft
- ◆ Assess and validate various e-noses
- ◆ Establish damage process and failure of e-nose
- ◆ Early failure mechanism by environmental storage and thermal cycling tests
- ◆ Packaging Reliability and E-Nose reliability



Introduction

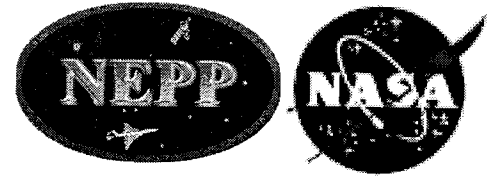


- ◆ Electronic Nose, New Technology Infusion on Space Shuttles, International Space Station (ISS)
- ◆ Demonstrated the operation of polymer based sensors based on Dr. Nathan Lewis of Caltech for use in sensing arrays
- ◆ E-Nose was flown on STS-95 to determine its utility as an air quality/incident monitor in crew habitat on a spacecraft
- ◆ JPL has developed, built and demonstrated a low power, miniature gas sensor which has capability to identify various gas species present in the recirculated breathing air of the space shuttle.

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Introduction



- ◆ Constituents of breathing air in a closed chamber in which air is recycled (Space station, space shuttle, etc.)
- ◆ Air-quality is determined by collecting the samples and analyzing them on the ground using GC-MS
- ◆ Miniaturized e-nose capable of identifying contaminants in the breathing environment at ppm or ppb levels would greatly enhance the capability for monitoring the quality of recycled air as well as providing notification of presence of dangerous gases.
- ◆ An e-nose is an array of non-specific chemical sensors, controlled and analyzed electronically, which mimics the action of nose by recognizing patterns of response to vapors
- ◆ JPL/NASA needs such e-noses

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TYPES OF SENSORS



- ◆ Conductivity sensors (metal oxide and polymer)
- ◆ Piezoelectric sensors
- ◆ MOSFET
- ◆ Optical
- ◆ Spectrometry
- ◆ Electrochemical
- ◆ Chemical



Electronic Nose



ELECTRONIC NOSE FOR SPACE STATION

- ✦ Incident monitor - real time air quality monitoring
- ✦ Identify and quantify target compounds at SMAC level
- ✦ Low mass, low power device
- ✦ Requires little crew time for maintenance and calibration

	Analysis Time (min)	Concentration of Constituents	Discrimination of Constituents
ENose	.5 - 15	0.01 - 10,000 ppm	good for target set
GC-MS	10 - 100	< 10 ppb	very good
VOC	1- 5	.1 - 2000 ppm	poor
FID	1 - 5	.1 - 50,000 ppm	poor
Smoke Alarm	.5 - 5	1 - 10 ppb	none

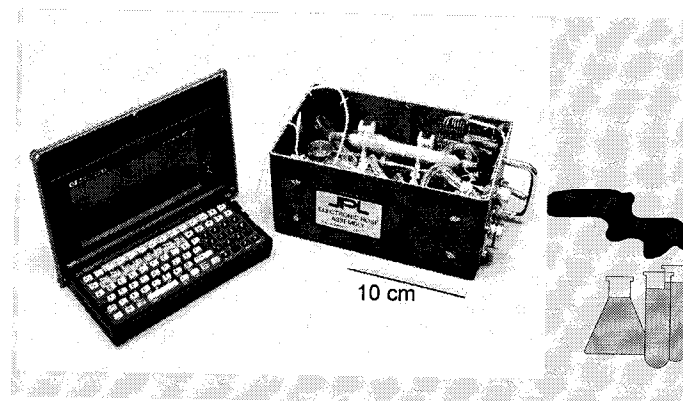


HUMAN NOSE

- ◆ array of thousands of sensors
- ◆ broad band capability
- ◆ trainable to new odors
- ◆ data acquisition in the brain
- ◆ analysis by true Neural Network processing; pattern recognition

LIMITS ON HUMAN NOSE

- ◆ fatigue
- ◆ becoming accustomed to an odor
- ◆ insensitivity to some compounds
- ◆ toxicity of some contaminants.



JPL/CALTECH ELECTRONIC NOSE

- ◆ array of a few tens of sensors
- ◆ thin film polymer based sensors
- ◆ broad band capability
- ◆ polymers selected to respond to particular compounds
- ◆ trainable to new analytes
- ◆ data acquisition by computer
- ◆ data analysis by computational methods and pattern recognition

LIMITS ON ENOSE

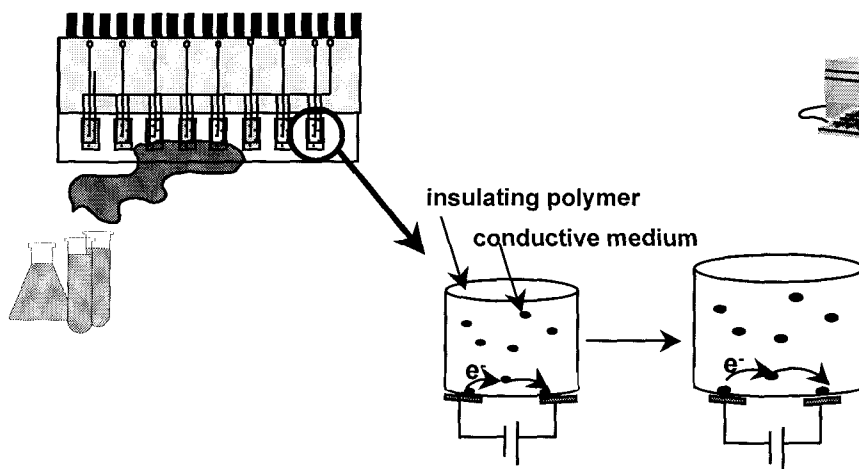
- ◆ insensitivity to compounds; can be overcome by sensor film selection

WHAT IS AN ELECTRONIC NOSE?

An array of non-specific chemical sensors, controlled and analyzed electronically, which mimics the action of the mammalian nose by recognizing patterns of response

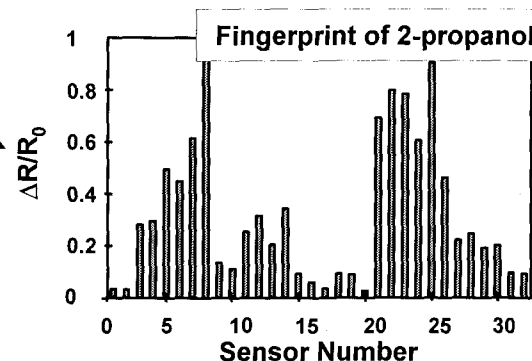
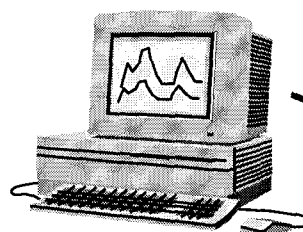
1. ENose measures background resistance in each sensor and establishes R_0 .

2. Contaminant comes in contact with sensors on the sensing head.



3. The sensing media, polymer films loaded with a conductive medium such as carbon black, change resistance by swelling or shrinking as air composition changes.

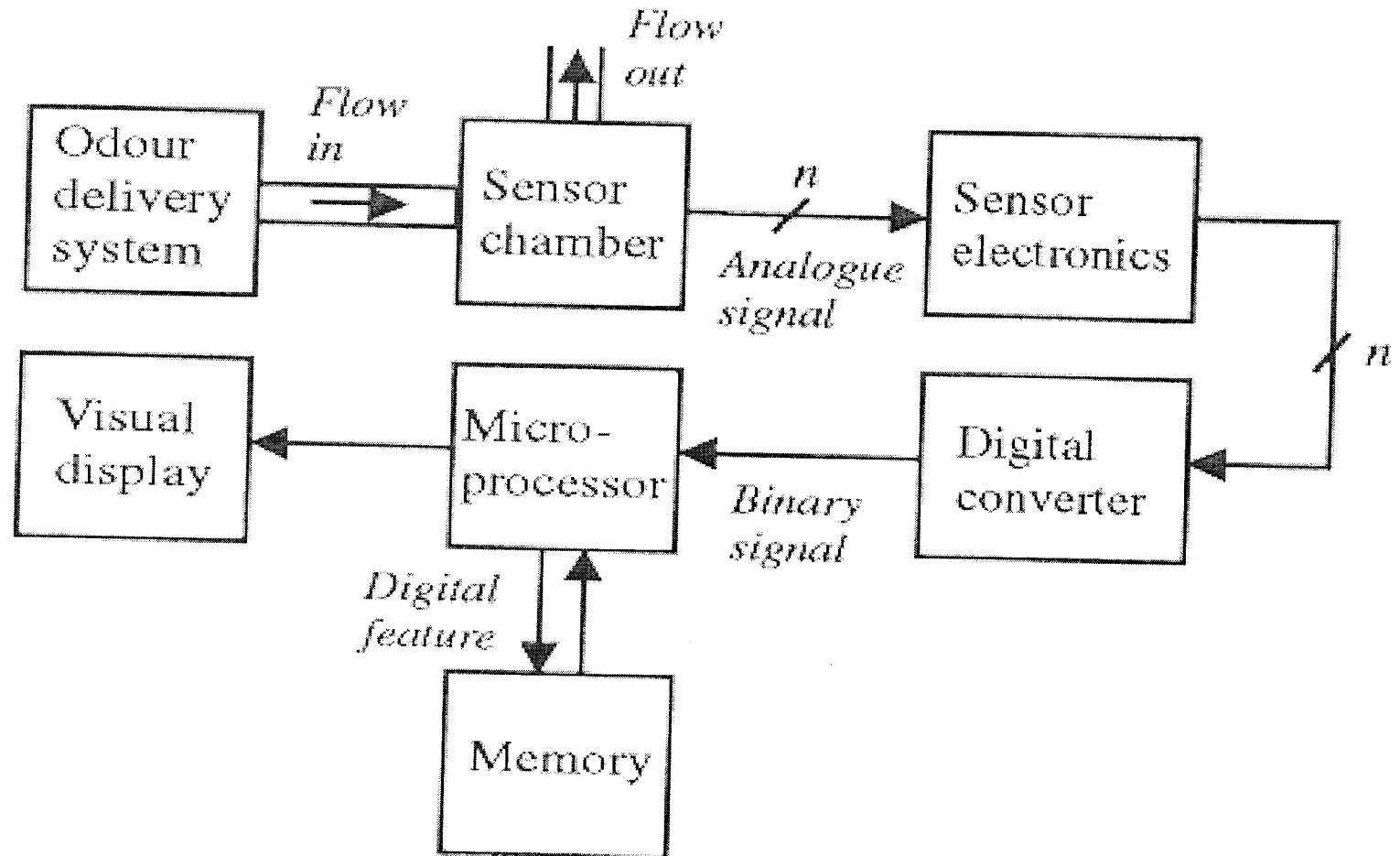
4. Resistance is recorded by a computer, the change in resistance is computed, and the distributed response pattern of the sensor array is used to identify gases and mixtures of gases



5. Responses of the sensor array are analyzed and quantified using software developed for the task.

2-propanol, 300 ppm

Basic components of an electronic nose instrument system

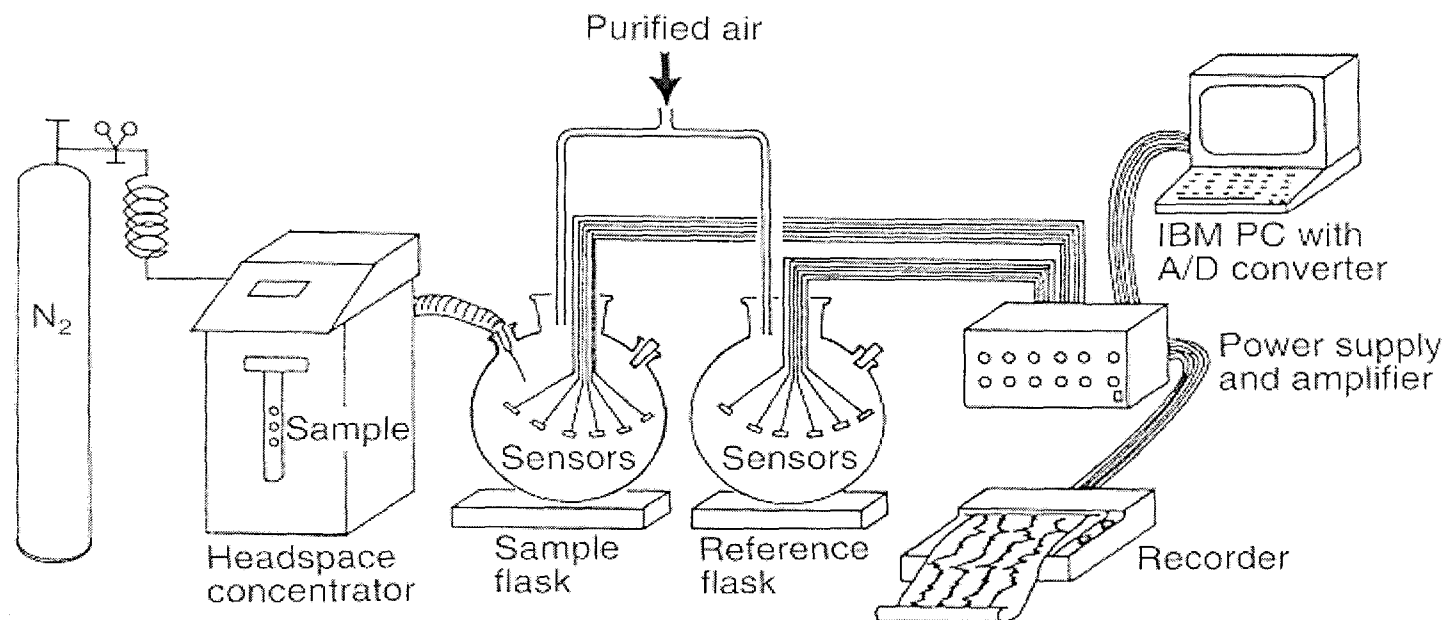


Ref.: Gardner and Bartlett

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Electronic Nose Instrumentation

- Head space sampling and Flow injection (carrier gas may be used to carry the odorant)

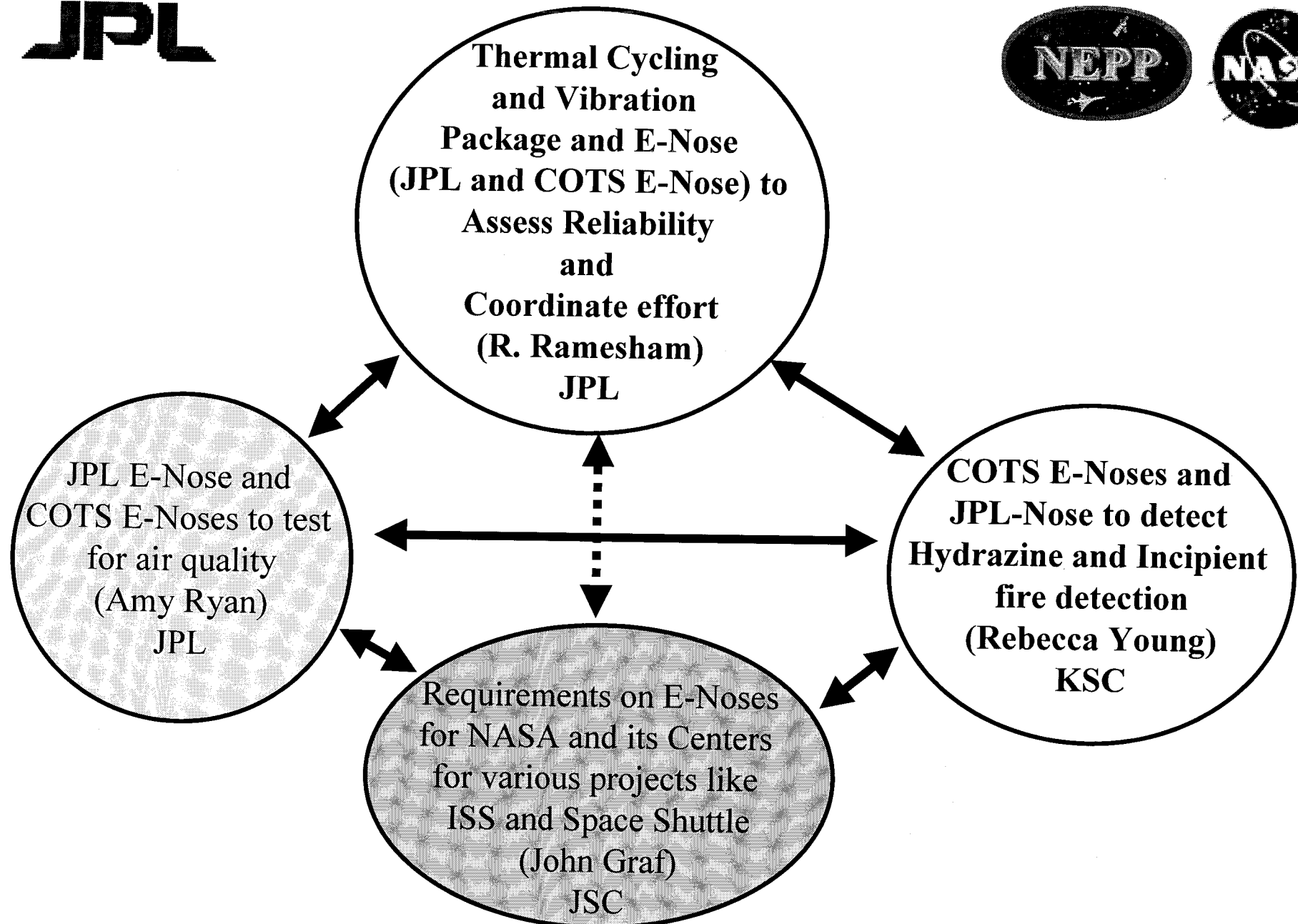


Inexpensive, forced mixing; Laborious and time consuming, temperature of odour and odour sensor

Ref.: Aishima 1991

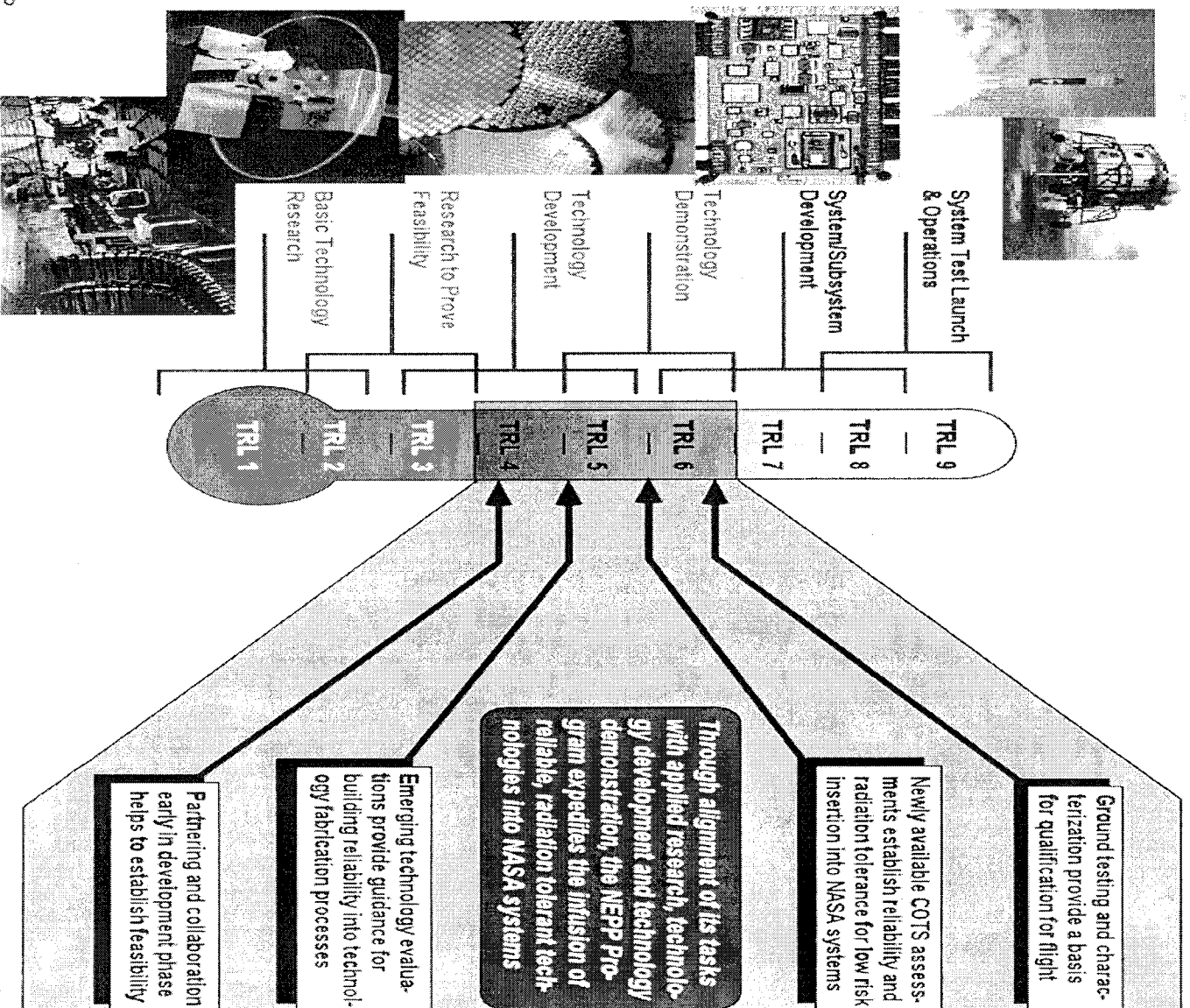
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Packaging and Reliability Assessment of Electronic Noses

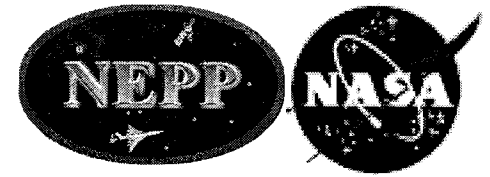




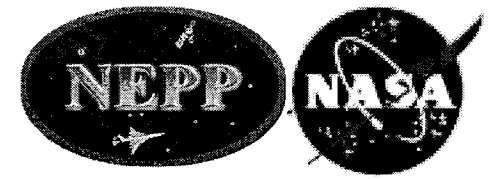
NEPP and TRLs: A Path to Rapid Technology Infusion



JPL *COTS E-nose companies and Odour Sensors*



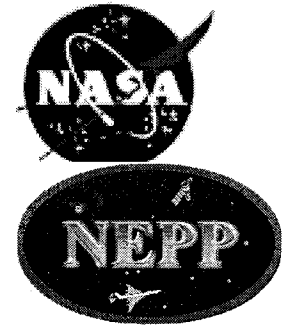
- Tekmar Co, HP, Sensidyne, Cyrano Sciences, Mosaic Industries, St. Croix Sensory Inc., Agilent Technology, Scientist Illumina, Inc., USA
- Figaro Engineering Inc., National, and New Cosmos Electric, Japan
- Aromascanner, Cogent Ltd., UK
- Bloodhound, UK
- Mastiff Electronic Systems, UK
- Neotronics, UK (e-Nose 4000 and 5000)
- Alpha MOS and Europhor Instruments, France
- HKR Sensor System, MoTech, Karlsruhe Research Center, Germany
- Lennartz Electronics, Germany
- Nordic Sensor Technology, Sweden
- Array Tec
- Electronic Sensor Technology, LP
- 30 - 50 universities around the world (Caltech, JPL, NC state, etc.)



*World-wide market size and value of
electronic noses*

Year	Estimated number of units sold	Market value (\$ Million)
1993	5	0.32
1994	25	1.6
1995	100	6.4
1996	250	16.0
1997	500	32.0
2000	2500	160.0

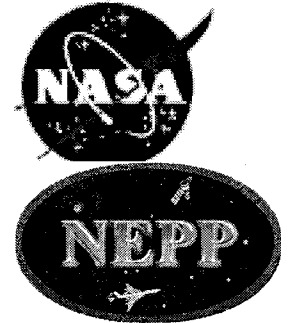
JPL COTS E-Nose Program in Summary



- ❖ Single set of reliability testing requirements for a wide applications may not be possible for evaluation of E-Nose technology
- ❖ Finding a common denominator and standardized testing based on the E-Nose key failure mechanisms are valuable to user community
- ❖ User can carryout any additional reliability testing needed for their application
- ❖ Standardized test methodology will reduce unclear communication between users and suppliers

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JPL COTS E-Nose Program in Summary

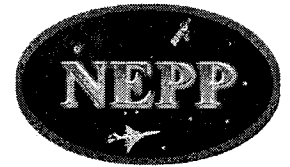


- ❖ Start with high volume COTS type E-Nose components that have potential for high reliability application
- ❖ Their availability and lower cost, a large number of these components can be tested to generate statistically meaningful reliability data.
- ❖ JPL has initiated COTS E-Nose Program with objectives of understanding quality and reliability assurance associated with implementation of this technology and help to build needed infrastructure.

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Evaluation of E-Noses and Respective IC Package



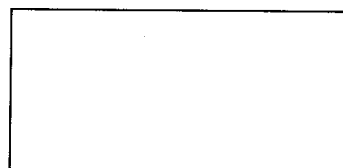
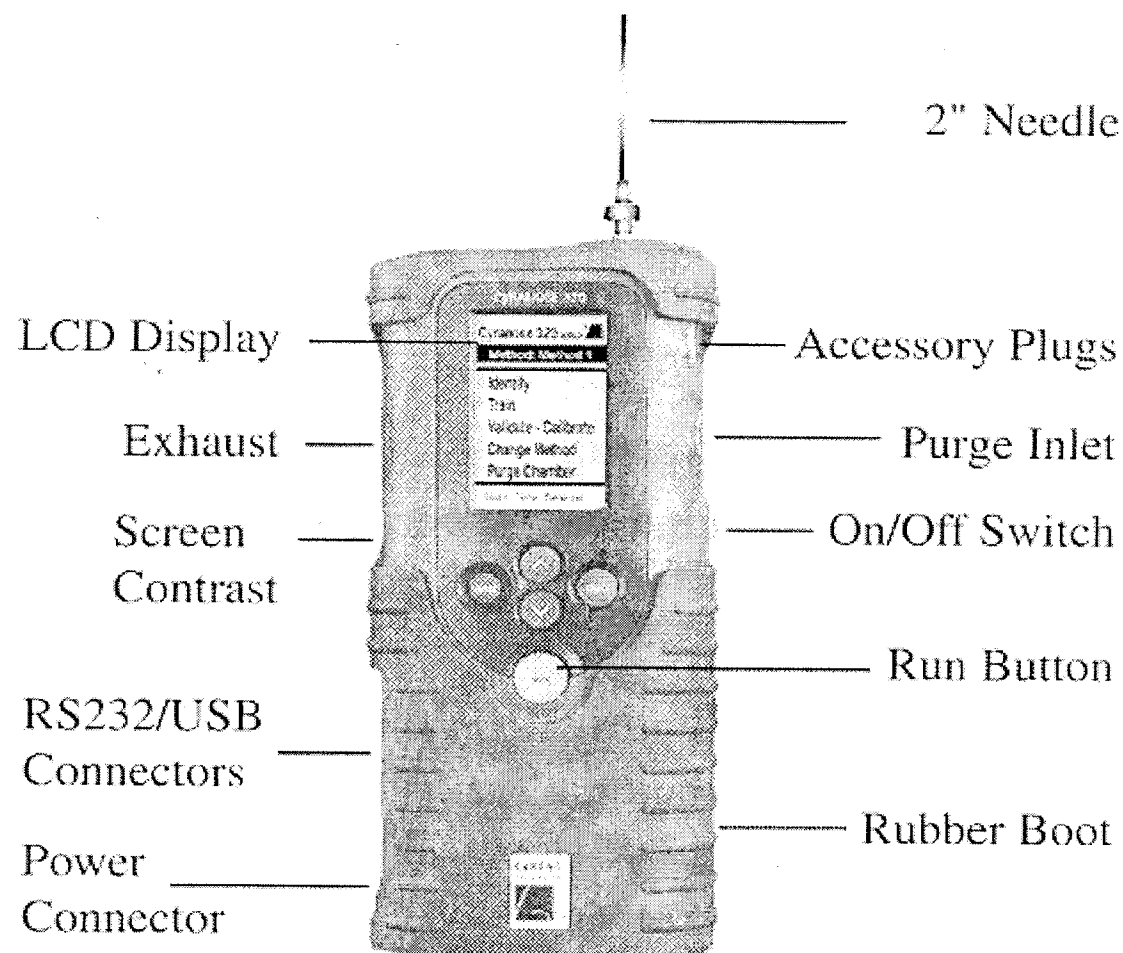
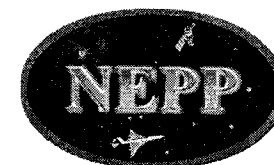
- * JPL E-Nose**
- * KAMINA**
- * SAM Detect**
- * Cyranos's E-Nose**
- * WMA Airsense PEN2 E-Nose**

Demonstrator for sensitive detection and discrimination of overheated wire insulations based on the KAMINA technology





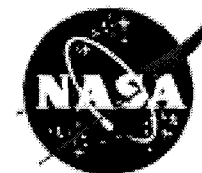
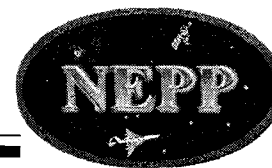
Packaging and Reliability Assessment of Electronic Noses



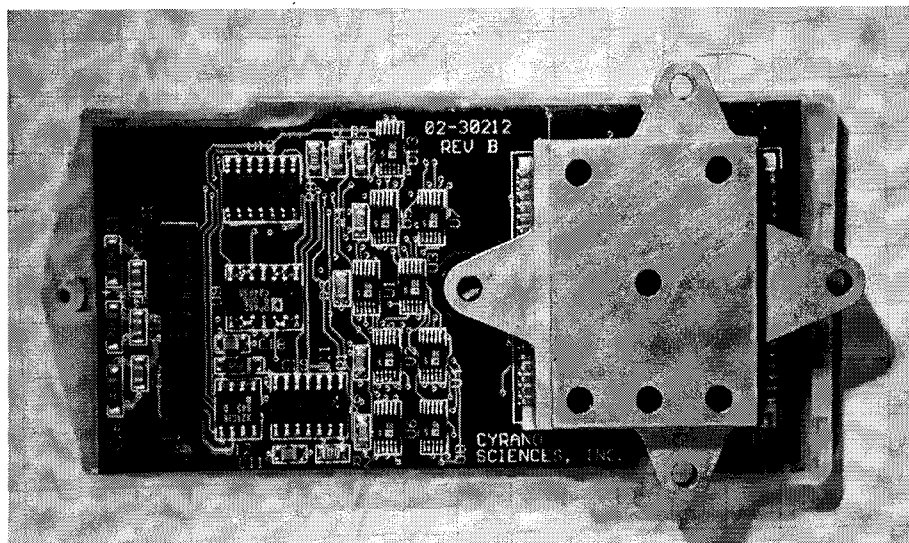
The assembled Cyranose 320.

JPL

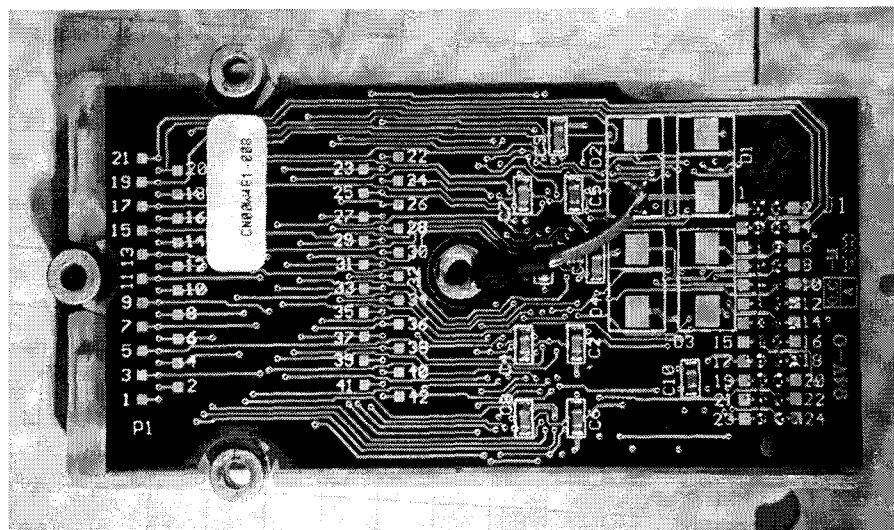
Cyranose 320



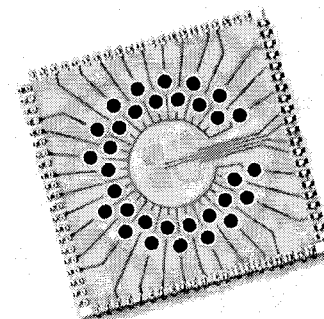
**Cyranose
320**



Front side of the IC



Backside of IC

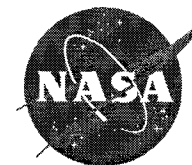


**Schematic of
E-Nose**

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Electronic Nose

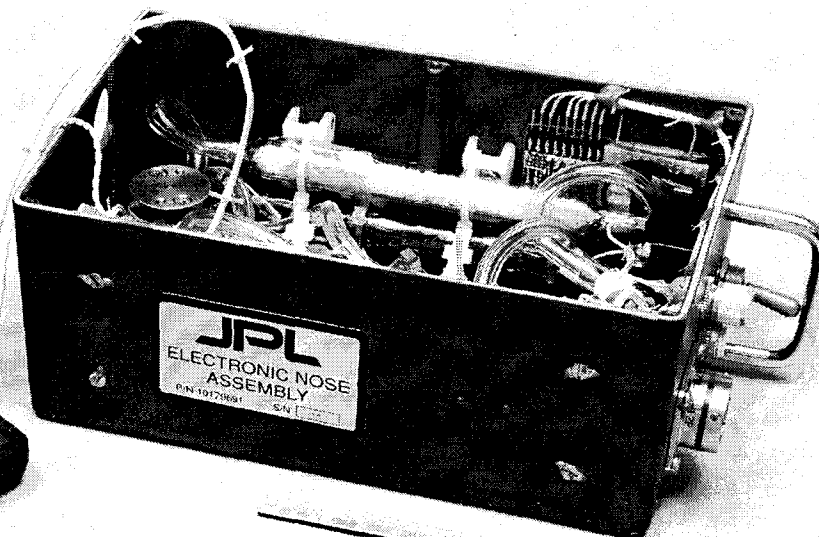
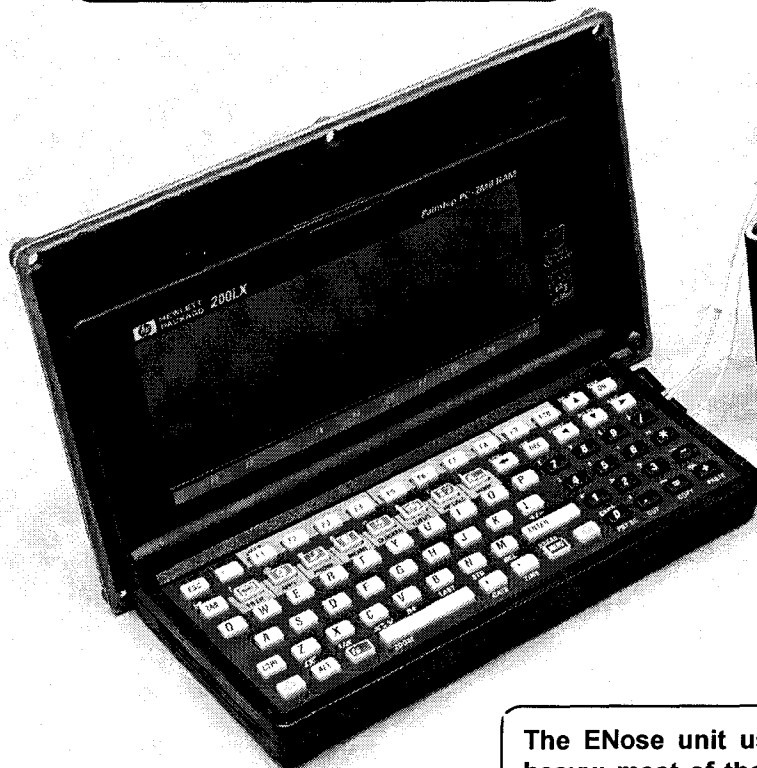


ELECTRONIC NOSE FLIGHT EXPERIMENT

Volume: 2000 cm³

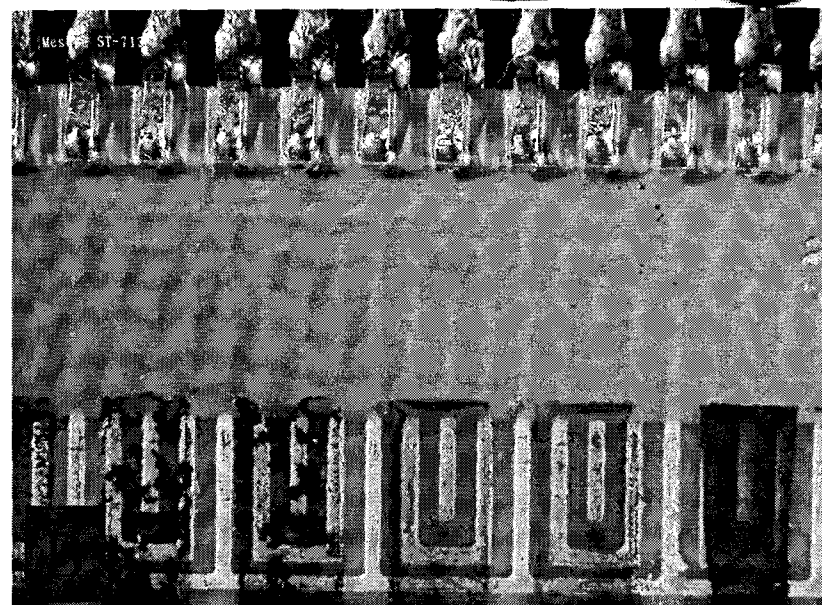
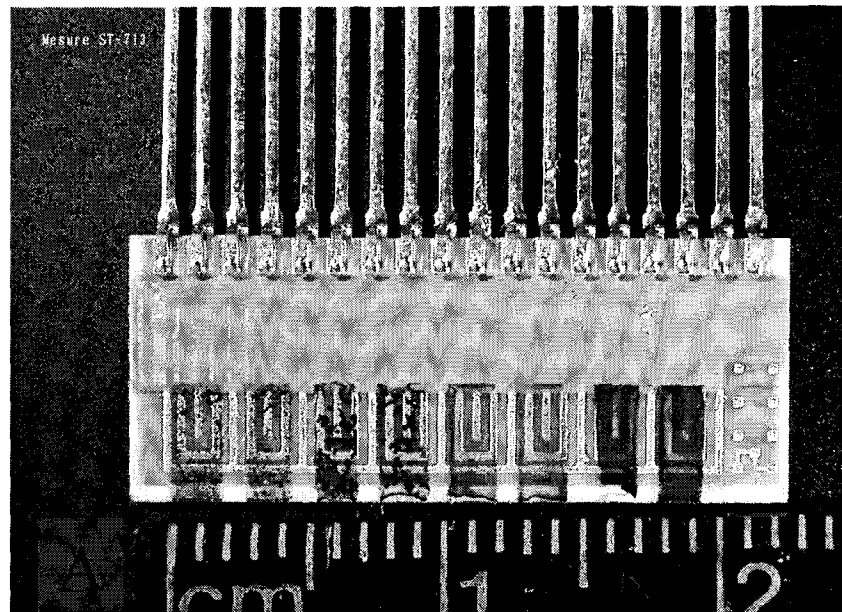
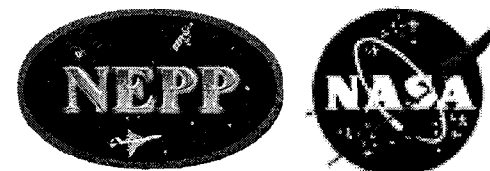
Mass: 1.4 kg

Power: 1.5 W ave., 3 W peak



10 cm

The ENose unit used in the Flight Experiment was relatively large and heavy; most of the volume and mass comes from the container required for use in crew area in the Space Shuttle. A device without such a container requirement would occupy ~700 cm³ and mass would be <.5 kg.



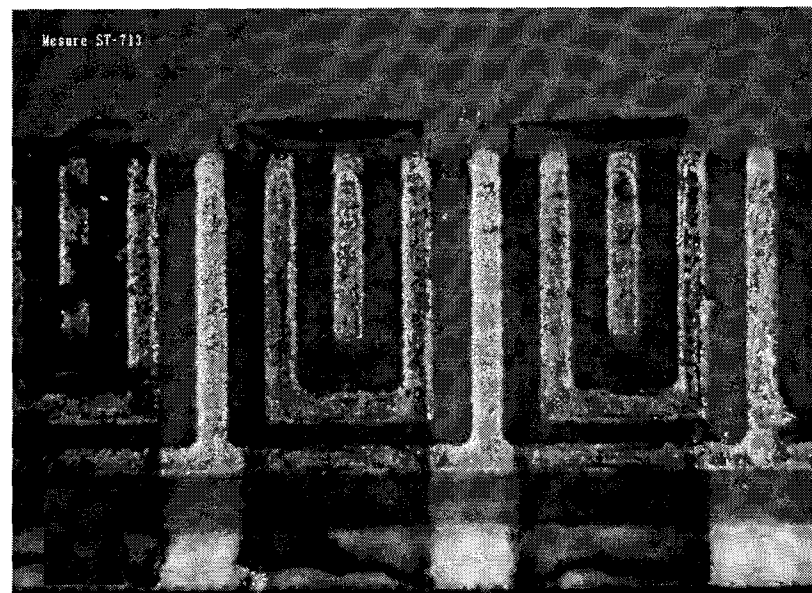
JPL E-Nose Sensor Array

A: Complete Sensor array

**B: Magnified view of A
showing sensors
and interconnects**

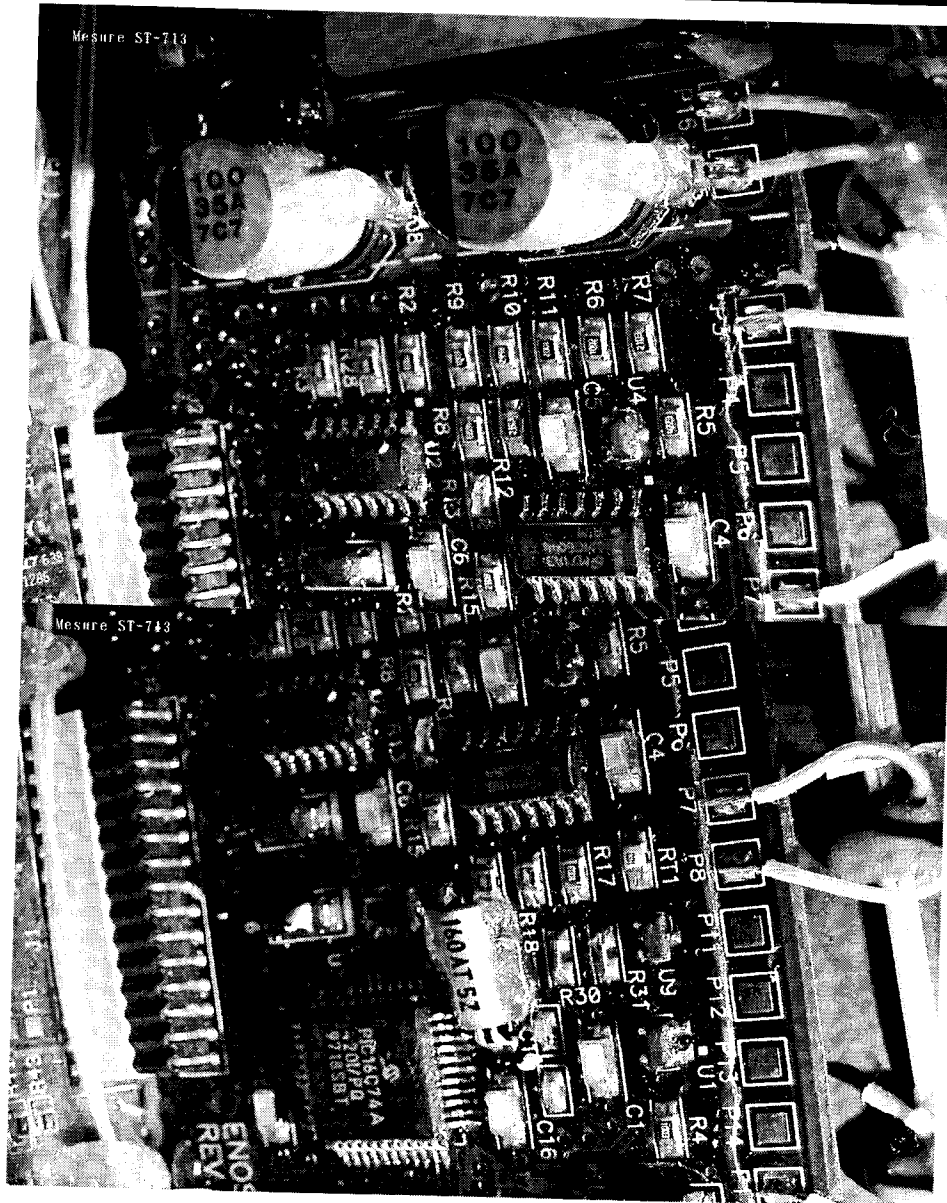
**C: Magnified view of B
showing the sensors**

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JPL E-Nose IC Package



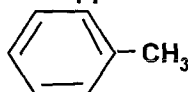
Electronic Package Associated
with JPL E-Nose that was used
in STS-95 Flight Experiment.

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FINGERPRINT RESPONSE OF ARRAY

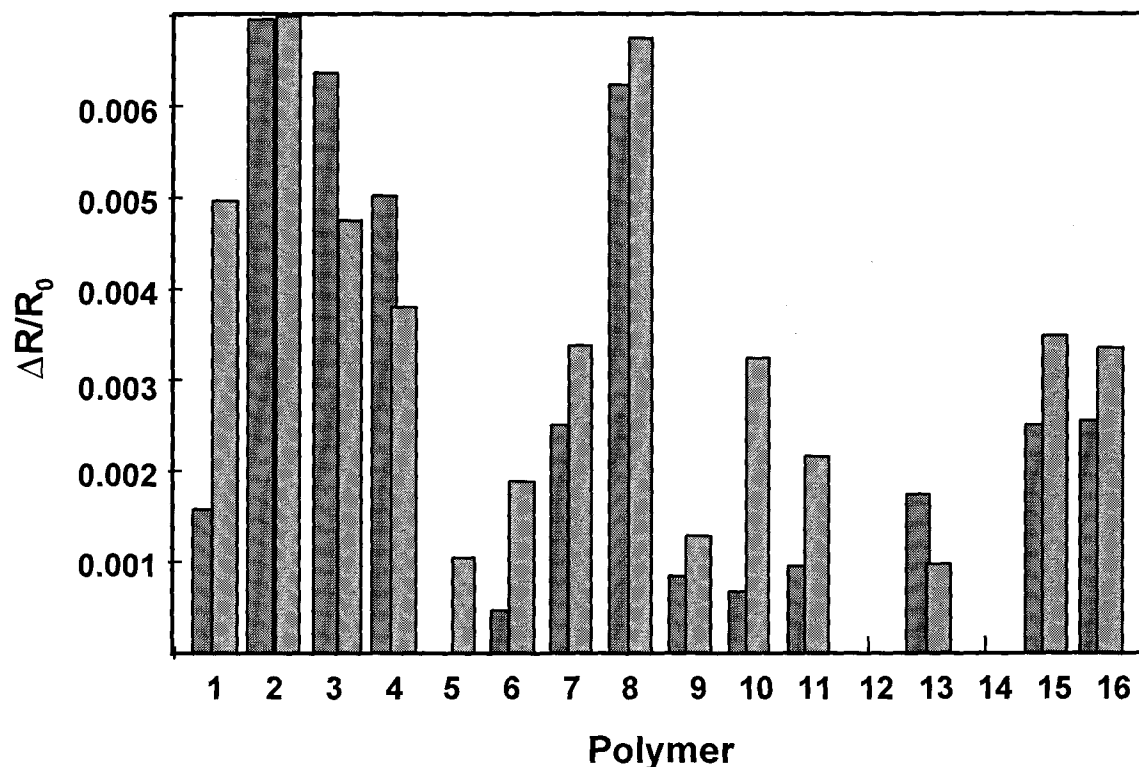
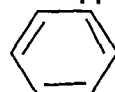
toluene

50 ppm



benzene

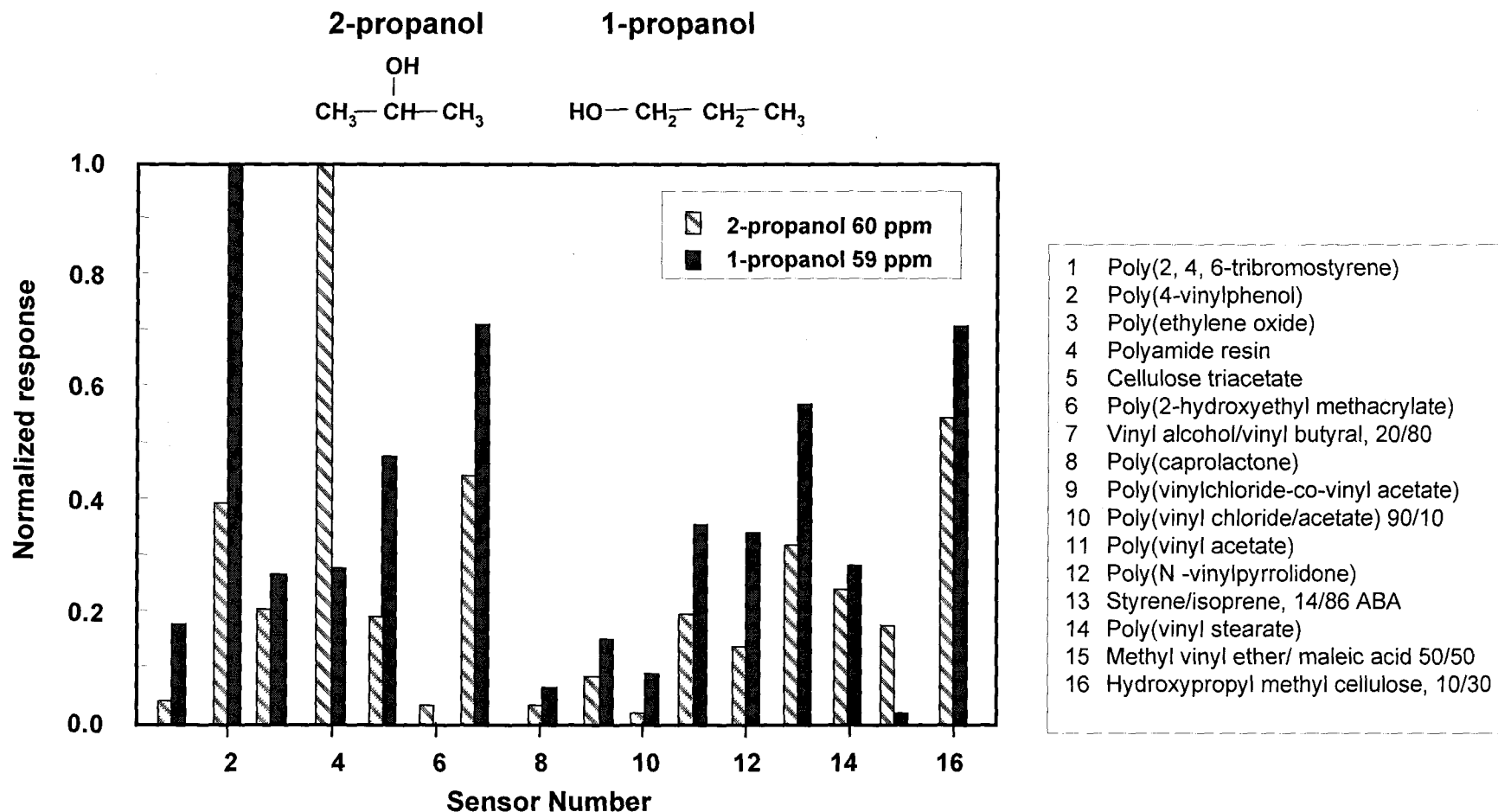
50 ppm



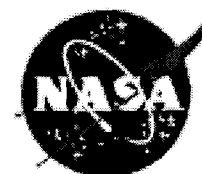
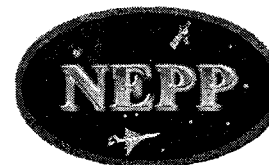
- 1 Poly(2, 4, 6-tribromostyrene)
- 2 Poly(4-vinylphenol)
- 3 Poly(ethylene oxide)
- 4 Polyamide resin
- 5 Cellulose triacetate
- 6 Poly(2-hydroxyethyl methacrylate)
- 7 Vinyl alcohol/vinyl butyral, 20/80
- 8 Poly(caprolactone)
- 9 Poly(vinylchloride-co-vinyl acetate)
- 10 Poly(vinyl chloride/acetate) 90/10
- 11 Poly(vinyl acetate)
- 12 Poly(N -vinylpyrrolidone)
- 13 Styrene/isoprene, 14/86 ABA
- 14 Poly(vinyl stearate)
- 15 Methyl vinyl ether/ maleic acid 50/50
- 16 Hydroxypropyl methyl cellulose, 10/30

Similar compounds can be distinguished by their fingerprints. Benzene and toluene are both aromatic, and have similar but distinguishable response patterns.

RESPONSE PATTERNS OF ISOMERS

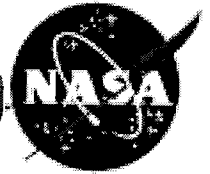
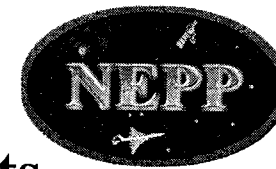


Isomers of propanol have similar but distinguishable response patterns.



Detection of simple odors by E- nose

Simple odor	No of odors	No/Sensor type
Alcohol's, ketones, alkanes, alkenes, sulfides	11	12/SAW
Pungent, ethereal, minty	47	7/MOS
Methanol, ethanol, propanol	3	3/MOS
Alcohol's	5	12/MOS
Alcohol's, terpenes, pyrazines	24	6/MOS
Methanol, ethanol, propanol	3	5/CP
Water, propanol, ethyacetate, acetone	4	3/CP
Alcohol's	5	20/CP
Toluene, n-octane (and mixtures)	2	6/BAW



Operational and Detection Requirements

Assess COTS E-Noses and JPL E-Nose for International Space Station (ISS) at 1 atmosphere pressure, 30 – 50 % relative humidity, and at a temperature of 25 – 35°C.

Assess the reliability of E-Nose for several days (~15 days)

Detect the compounds at or below 1 hour SMAC or choose 3 or 4 compounds in the target list as shown in Table 1 at or below 1 hour SMAC.

Target compounds are Toluene, Ammonia, 2-propanol, Methanol, Hydrazine, and outgassing from overheating of electrical wires used on board of Space Shuttle and International Space Station.

Assess/Evaluate the COTS E-Noses for 1 ppm hydrazine in an airlock at 5 psi in about 3 minutes.

Assessment of thermal degradation events in space shuttle. Wire insulation on flight approved materials list where systems are most likely to overheat.



Target compounds for electronic nose shuttle experiment and JPL limits of detection.

Compound	Detected on the Shuttle, ppm	1 hr SMAC, ppm	Detection Limit ppm	Testing, ppm
Alcohols				
Methanol	<1	30	5	5-300
Ethanol	0.5 - 5	2000	50	10-130
2-propanol	0.4-4	400	50	30-160
Ammonia	0	30	20	10-50
Benzene	<0.1	10	10	10-150
CO ₂	320	13000	---	---
Indole	0	1	0.03	0.006-0.06
Hydrazine	0	4	???	???
Methane	1-10	5300	3000	1000-7000
Formaldehyde	0	0.4	25	25-510
Freon 113	0.1 - 1	50	20	20-600
Toluene	0.4 - 4	16	15	15-60

Electronic nose sensor technologies

Sensor type	Principle of operation	Fabrication methods	Availability	Sensitivity
Metal oxide	Conductivity	Microfabricated	Several commercial types	5-500 ppm
Conducting polymer	Conductivity	Microfabrication Electroplating Screen printing	Several commercial types	0.1 – 100 ppm
Quartz crystal microbalance	Piezoelectricity	Screen printing Wire bonding Microelectromechanical systems (MEMS)	Several commercial types	1 ng mass change
Surface acoustic wave (SAW)	Piezoelectricity	Microfabrication Screen printing	Several commercial types	1 pg mass change
MOSFET	Capacitive charge coupling	Microfabrication	Several commercial types	ppm
Gas Chromatography	Molecular spectrum	MEMS, precision machining	Several commercial types	Low ppb
Mass spectrometry	Atomic mass spectrum	MEMS, precision machining	Several commercial types	Low ppb

Commercial Electronic Noses Available to-date in the Market

Company Name	Website	Product name
Agilent Technologies/Hewlett-Packard	http://www.agilent.com/Top/English/index.html	HP4440A Chemical Sensor HP4440B, Chemical Sensor
Cyrano Sciences, Inc.	http://cyranosciences.com/	Cyrano 320
Electronic Sensor Technology "zNose"	http://www.estcal.com/	4100 Fast GC Analyzer 7100 Fast GC Analyzer
Microsensor Systems Inc.,	www.sawtek or www.microsensorsystems.com	VaporLab
Alpha-Mos	http://www.alpha-mos.com/	FOX 4000, FOX 2000, FOX 3000, FOX 5000, Prometheus, Kronos, Centauri, ASTREE, Odor Scanner 100
Lennartz-Electronic	http://www.lennartz-electronic.de/Pages/English/Homepage_english.html	Moses II (Modular Sensor System)
Motech Sensorik /Nordic Sensor or Applied Sensors		NST 3210, NST 3220, NST 3220A, VOCmeter, VOC check
		OEM Modules
Aromascan /OSMETECH	http://www.aromascan.com/	Aroma Scanner
WMA Aisense Analysentechnik GmbH	http://www.aisense.com/uk/main.htm	PEN
RST Rostock	http://www.rst-rostock.de/d/index_prod_sens.html http://www.rst-rostock.de/	SamSystem
		SamDetect
		SamDirect
		SamSelect
Bloodhound Sensors, Ltd.	www.leeds.ac.uk/ulis/bloodhound/frames/fr_home.htm	Bloodhound, BHI14'
Zellweger Analytics	http://www.detect-measure.com/z.htm http://www.detect-measure.com/default.htm	Search point optima
		Searchlineexcel
		705 sensor
Neotronics Scientific Ltd.,		e-nose 4000 e-nose 5000
HKR Sensorsysteme, GmbH		Olfactometer, Chemosensory system QMB-6, MS-Sensor, SensiTOF
Mosaic Industries		Rhino
Array Tec		Scan Master II
Mastiff Electronic Systems		Scentinel
Europor Instruments		Alabaster-UV
New Cosmos-Electric Co.		Portable odor level indicator, XP-329
Sensidyne, Inc.,	http://www.sensidyne.com/	Portable odour level monitor
National		Oral checker
Marconi Applied Technologies	www.marconi-technologies.co.uk	e-Nose 5000
GSG-Analytical	http://gsg-analytical.com/enose.htm http://gsg-analytical.com/english/amos2.htm#	MOSES II
Oligosense bvba	http://chem-www.uia.ac.be/	Development
Osmetech plc	http://www.osmetech.plc.uk/ http://www.osmetech.plc.uk/technology/techback.html	MultiSampler-SP, And Sensors, Core sensor module
Smart Nose	http://www.smartnose.com/ http://www.smartnose.com/specificationsTechnique.htm	Smart Nose 300
Element Ltd., or RKS Sensor Systems	http://www.element.is/	FreshSense
EnviroNics Industry Oy	http://www.uku.fi/aitokset/ympekem/Bio/imcell.html	MGD-I
KHAMINA E-Nose	www.holzschuh-usa.com	KHAMINA Demonstrator

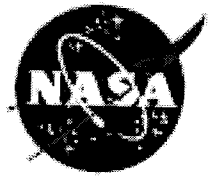


Electronic nose sensor technologies

Sensor type	Principle of operation	Fabrication methods	Sensitivity
Metal oxide	Conductivity	Microfabricated	5-500 ppm
Conducting polymer	Conductivity	Microfabrication Electroplating Screen printing	0.1 – 100 ppm
Quartz crystal microbalance	Piezoelectricity	Screen printing Wire bonding Microelectromechanical systems (MEMS)	1 ng mass change
Surface acoustic wave (SAW)	Piezoelectricity	Microfabrication Screen printing	1 pg mass change
MOSFET	Capacitive charge coupling	Microfabrication	ppm
Gas Chromatography	Molecular spectrum	MEMS, precision machining	Low ppb
Mass spectrometry	Atomic mass spectrum	MEMS, precision machining	Low ppb



Reliability Issues



- Response reproducibility between sensors of nominally the same type. This is important for two reasons
- If a sensor is poisoned then it can be replaced without the need to fully recalibrate and retain the system.
- If the sensors are sufficiently reproducible in their response it becomes possible to train one sensor array and then use this same training set for any number of nominally identical arrays in other instruments at different locations.
- Sensitivity to changes in temperature, humidity, and flow rate are also important characteristics. Odour sensors should be insensitive to changes in temperature, humidity, and flow rate. Most sensors show some sensitivity problem.

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Reliability Issues



- These effects can be minimized by careful system design and sample handling which makes the instrument more complex, expensive, and limit sample throughput.
- In portable electronic noses it will be essential to overcome, or at least adequately compensate for, the effects of changes in temperature and humidity on the sensors baseline and on the magnitude of their responses.
- Sensor physical size need to be kept low. If the sensor is large then sample volume is large, which can lead to slow response time and poor sensitivity because of dilution.
- Microfabricated sensor array can meet these requirements.



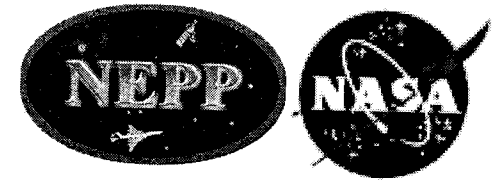
Important instrument and test conditions when employing electronic nose technology

Parameter/Condition	Effect
Temperature	causes significant changes in all types
Humidity	Significant variation in many sensors
Reference gas	Stable baseline signal, reduces interference
Flow rate	Sensor output varies
Odour concentration	Natural variations cause errors in sensors
Odour profile	Repeatable concentration profile may improve discrimination power

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Package

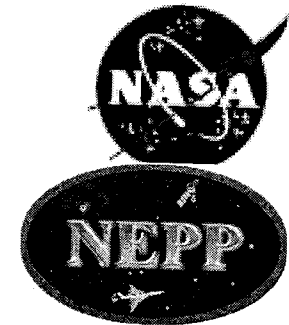


- ◆ 32 Sensor head in an e-nose arrangement on 4 substrates each with 8 sensors
- ◆ Hybrid microelectronic co-fired ceramic alumina substrate
- ◆ Thick film screen printing
- ◆ A guard ring around each sensor
- ◆ 16 polymers used
- ◆ Two sensors for each polymer
- ◆ Four polymers on each substrate
- ◆ Thermistor is used to control temperature
- ◆ Gold contacts

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Space Systems

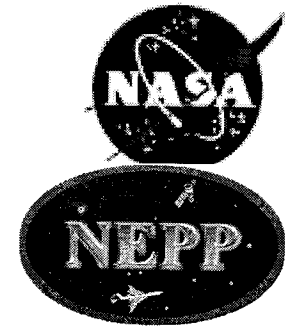


- Qualification of the devices for space systems
- Reliability
- Battery of test methods to establish above to validate the efficacy of E-Nose
- Variety of E-Nose configurations makes difficult in terms of qualification procedures
- Building in quality E-Nose

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Space Systems

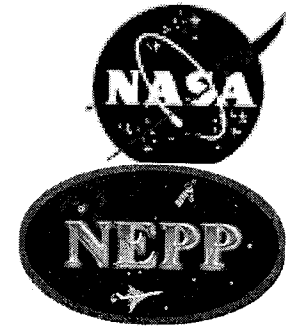


- Minimization of size and weight
- Improve performance
- Enhance the awareness of E-Nose to designer of space systems
- Advanced electronics packaging
- Radiation tolerant microcircuits



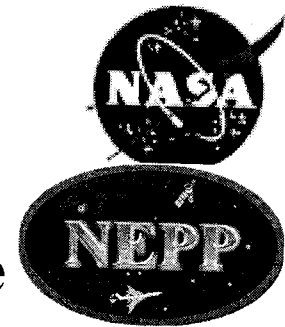
Qualification

- ◆ Suitability of technology for a particular application
- ◆ Inadequacy of military standards
- ◆ Required amendment of standards
- ◆ Risk assessment or factor
- ◆ Assurance of new technologies





Qualification Process



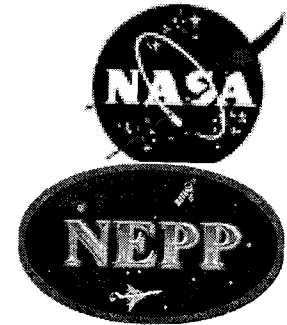
- ◆ Identification of technology failure modes
- ◆ Certainty of non-failure modes during the life of the mission
- ◆ Development of test methods for demonstrating failure modes (This is the current practice)
- ◆ Hermetic encapsulation
- ◆ Availability of Packaging support equipment
- ◆ Cost of packaging is a key acceptance criteria
- ◆ Space is one of the last place for the debut of a new technology

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Environmental

- Conditions of storage
- Usage environment
- Qualification testing
- Incubation period of space electronics assemblies in various storage locations
- Thermal cycling
- Vibration due to launch and pyrotechnic release actions
- Hermetic packaging
- Outgassing products from polymeric materials



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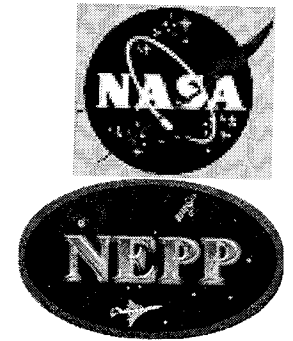
JPL Environmental (continued)



- Shock
- Humidity
- Radiation
- Corrosion
- Mismatches in TCE
- Extremes in ambient temperatures
- Thermomechanical shock



Issues to Address by Space Community



- New ways to designing systems
- Fully exploit the advantages of E-Nose and COTS E-Nose, ASIM technology
- Characterization of materials and systems at micron level
- Development of low-cost design, production, and test technologies
- Packaging and interconnection approaches
- Software interface
- Development of new product-assurance tools
- Versatile electronics package intended to drive/control microinstruments
- Software tools for data acquisition and analysis

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Factors Influencing Package Reliability



- Residual stress
- Stress relief
- Hermeticity
- Thermal performance
- Chemical stability
- Protection during packaging
- Shock resistance
- Electrical isolation
- Cost issues

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Package

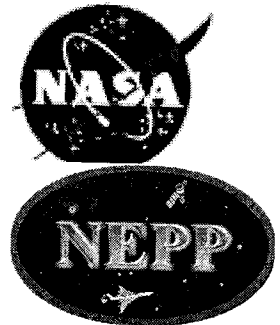


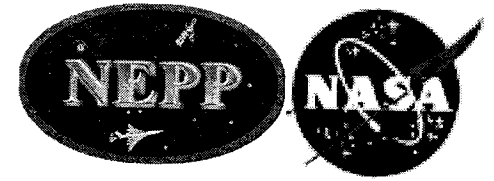
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JPL Packaging Reliability Concerns

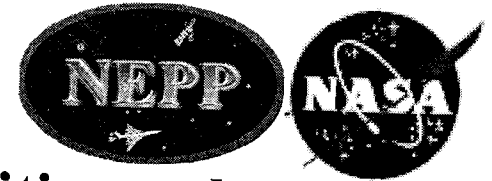
- ❖ Typical mechanical fatigue
- ❖ Contamination
- ❖ E-Nose fatigue
- ❖ Media compatibility
- ❖ Device passivation and Alternative chip mounting techniques





Future Prospects of E-Nose

- Likely to make many advances in the near future
- Presence of commercial instruments to stimulate interest
- Multitype noses
- Micro and nanotype e-noses
- ASIC Electronics
- Adaptive neural networks
- Smarter, smaller, and cheaper e-noses



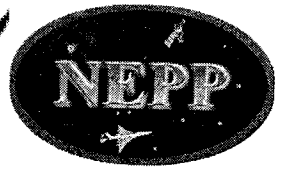
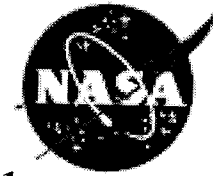
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Conclusions



- ✿ Assessing and evaluating the reliability of JPL and Commercial E-noses using the work-plan described for organic, inorganic and incipient fire detection.
- ✿ Thermal cycling and vibration tests of electronic packages such as driver/control electronics, e-noses under extreme temperatures will be performed for present and future NASA missions.
- ✿ Optical and non-destructive evaluation of electronic packages and e-noses before and after extreme cold temperature cycling.
- ✿ Prepare inspection criteria, develop protocols for flight experiment and shuttle crew, prepare quality assurance and reliability guidelines.
- ✿ Identified Four commercial E-Noses for evaluation of sensor head and respective IC packages
- ✿ Detected N_2H_4 at PPB level using KAMINA

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